

10/701192

PTO 06-0411

CY=JA DATE=19890822 KIND=A  
PN=01-208456

METHOD FOR CHANGING ELECTRON GUN IN VACUUM VESSEL  
[Shinkuyoki ni okeru denshiju no kokan hoho]

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UNITED STATES PATENT AND TRADEMARK OFFICE  
Washington, D.C. October 2005

Translated by: FLS, Inc.

PUBLICATION COUNTRY	(19):	JP
DOCUMENT KIND	(12):	A
	(13):	PUBLISHED UNEXAMINED PATENT APPLICATION (Kokai)
PUBLICATION DATE	(43):	19890822 [WITHOUT GRANT]
PUBLICATION DATE	(45):	19890822 [WITH GRANT]
APPLICATION NUMBER	(21):	63-030968
APPLICATION DATE	(22):	19880215
PRIORITY DATE	(32):	
ADDITION TO	(61):	
INTERNATIONAL CLASSIFICATION	(51):	C23C 14/30
DOMESTIC CLASSIFICATION	(52):	
PRIORITY COUNTRY	(33):	
PRIORITY NUMBER	(31):	
PRIORITY DATE	(32):	
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TITLE	(54):	METHOD FOR CHANGING ELECTRON GUN IN VACUUM VESSEL
FOREIGN TITLE	[54A]:	Shinkuyoki ni okeru denshiju no kokan hoho

## Specification

### 1. Name of this Invention

Method For Changing Electron Gun In Vacuum Vessel

### 2. Claim(s)

Method for changing electron gun in vacuum vessel comprising (1) a vacuum vessel in which an electron gun is positioned at a specific location, (2) auxiliary vacuum chamber connected to the vacuum vessel, having opening/closing valves partitioning the vacuum vessel and open air side, and (3) electron gun transfer means which transfers the electron gun for replacement to the auxiliary vacuum chamber while the air side opening/closing valve is opened and the opening/closing valve at the vacuum vessel side is closed, and transfers the electron gun for replacement to a specific location of the vacuum vessel when the opening/closing valve at the vacuum vessel side is opened while the opening/closing valve at the air side is closed.

### 3. Detailed Explanation of this Invention

[Technological Field]

This invention pertains to a method of changing an electron gun in a vacuum vessel utilized by a vacuum depositing method or electron laser isotope separation method utilizing an electron gun.

[Conventional Technology]

For example, when producing a product by coating a metal with an electron gun using a vacuum deposition device, if the electron gun in the vacuum vessel is broken and needs to be replaced, after the

pressure in the vacuum vessel is temporarily released to air pressure, the gun is manually replaced with a replacing electron gun.

Fig. 3 is a diagram illustrating the above-mentioned vacuum depositing device. The vacuum vessel 1 contains a crucible 3 filled with metal (nickel) 2, electron gun 4 for heating and evaporating the metal 2 in the crucible 3, and vapor-depositing body (Pyrex glass) 5 which is to be taken out as a product after the evaporative metal is deposited. Also, the above-mentioned electron gun 4 is connected to an electron gun water-cooled pipe 6 and electron gun electric wire 7 from the outside of the vacuum vessel 1 to which a vacuum pump 8 is connected.

After the inner pressure of the vacuum vessel 1 is set to a vacuum state of approx.  $10^{-5}$  Torr, an electron beam is generated from the electron gun 4 as shown with the arrow "i" in the figure to dissolve and evaporate a portion of metal 2. As a result, this evaporated metal is deposited on the depositing body 5 as shown with the arrow "j", thereby creating a Pyrex glass product coated with metal.

As the method of heating the metal 2, although a heater (not shown) may be provided to the crucible 3, if the above-mentioned metal 2 is a high melting point material or highly corrosive material, selecting the material of the crucible 3 becomes difficult. Therefore, the heat-vapor depositing method using the electron gun 4 is considered more preferably. Also, the reason for vacuuming the

vacuum vessel 1 is for lowering the boiling point of the metal 2 and generating an electron beam efficiently (electron beam cannot be generated at a pressure of  $10^{-3}$  Torr or higher).

Hereafter, the process of replacing the broken electron gun is explained by referring to the time schedule shown in Fig. 4.

First, the vacuum vessel 1 is released for adjusting the inner pressure to an air pressure. Then, the broken electron gun 4 is transferred to the outside of the vessel. Next, after a replacement of electron gun is newly transferred into the vacuum vessel 1, and the vacuum vessel 1 is sealed, the vessel 1 is vacuumed using a vacuuming pump 8. Thereby, the vacuum-vapor depositing process can be restarted.

#### [Problems to be Solved by this Invention]

However, since the process of changing the electron gun described above requires a vacuum vessel opening/closing operation, electron gun transferring out/in operation, and re-vacuuming process, the actual changing process takes 15 hours, and moreover, at least 2 workers are needed.

This invention was developed to solve these problems. The object of this invention is to provide an electron gun changing method in a vacuum vessel, capable of changing the electron gun without releasing the vacuum states in the vacuum vessel while saving the time and labor when replacing the electron gun.

[Method for Solving the Problems and the Operation]

To achieve the object described above, this invention provides a method for changing electron gun in a vacuum vessel comprising (1) a vacuum vessel in which an electron gun is positioned at a specific location, (2) auxiliary vacuum chamber connected to the vacuum vessel, having opening/closing valves partitioning the vacuum vessel side and air side, and (3) electron gun transfer means which transfers the electron gun for replacement to the auxiliary vacuum chamber when the air side opening/closing valve is opened while the opening/closing valve at the vacuum vessel side is closed, and transfers this electron gun for replacement to a specific location in the vacuum vessel when the opening/closing valve at the vacuum vessel side is opened while the opening/closing valve at the air side is closed.

[Embodiment of this Invention]

Hereafter, an embodiment of this invention will be described while referring to figures.

Fig. 1 is a diagram illustrating the vacuum deposit device allowing the electron gun changing method of this invention. In the figure, the crucible 3 and vapor depositing body 5 in the vacuum vessel 1 are not shown.

An auxiliary vacuum chamber 10 is connected to the sidewall of a vacuum vessel 1 and a vacuum pump 11 is connected to this auxiliary vacuum chamber 10. An electron gun driving motor 12 is provided at the outside (open air-side) of this auxiliary vacuum chamber 10. A

drive shaft 13, which extends and contracts by the rotation of this motor 12 reaches the vacuum vessel 1 through the auxiliary vacuum chamber 1 when it is maximally stretched. An electron gun 14 for replacement is disposed in the auxiliary vacuum chamber 10, while an electron gun 16 is disposed at a specific location in the vacuum chamber 1. The electron gun water-cooled pipe 6 and electron gun electric wiring 7 for the electron gun 16 in the vacuum vessel 1 are connected through a couplings 18, 19.

On the other hand, the above-mentioned auxiliary chamber 10 is divided by the opening/closing valve (A) 20 and opening/closing valve (B) 21 respectively at the vacuum vessel 1 side and open air side. Also, an electron gun transfer rail 22 extends from the auxiliary vacuum chamber 10 to the positioning location of the electron gun 16 in the vacuum vessel 1.

That is, the vacuum vessel 1 is currently in the vacuumed state, and the vacuum vapor is deposited by the electron beam generated from the electron gun 16. At this time, an electron gun for replacement 14 has been transferred into the auxiliary vacuum chamber 10 and positioned onto the rail 22, and inside of the auxiliary vacuum chamber 10 is vacuumed to approx.  $10^{-5}$  Torr by the vacuum pump 11 while each opening/closing valve 20, 21 is closed.

By referring to the time schedule illustrated in Fig. 2, the following explains the electron gun replacing process when the electron gun 16 is broken.

First, the opening/closing valve (A) is opened, making the vacuum vessel 1 and auxiliary vacuum chamber 10 connected while they are in the vacuum state. Next, couplings 18, 19 are released, and the electron gun 16 in the vacuum vessel 1 is transferred from a specific positioned location to the location "a" as shown with the arrow A. Next, the drive shaft 13 is extended in the direction shown with the arrow "x" by the electron gun driving motor 12, and the electron gun 14 for replacement positioned in the auxiliary vacuum chamber 10 beforehand is transferred along the rail 22 as shown with arrow "B" and position "b", and then transferred into the vacuum vessel 1 and stationed at a specific location in the vacuum vessel 1. This electron gun 14 for replacement newly transferred in the vacuum vessel 1 is connected to a water-cooled tube 6 and an electrical wire by means of the couplings 18, 19, hence becoming the state for performing the vacuum vapor depositing process again. That is, since, unlike the conventional method, the gun exchange process (i.e., gun 16 → gun 14) does not require the step of releasing air from the vacuum vessel 1 and re-vacuuming the vacuum vessel 1, the time needed for exchanging the guns can be shortened to only 2 hours which is the duration from the time of opening the opening/closing valve 20 for transferring the electron gun 14 for replacement along the rail 22 to the time of disposing the electron gun 14 at the specific location in the vacuum vessel 1.

Once the vacuum depositing process is restarted in this manner, the opening/closing valve (A) is closed, and opening/closing valve (B) is opened to release the inside of auxiliary vacuum chamber 10 to the air. Then, a reserved gun (not shown) is transferred into the auxiliary vacuum chamber 10 from outside of the chamber 10 as a new electron gun 14 for replacement. After this process, the auxiliary vacuum chamber 10 is vacuumed by the vacuum pump 11 and is waited for the operation for the next exchange of the electron gun 16 in the vacuum vessel 1.

In this case, since the transfer and positioning operation of the electron gun 14 for replacement is performed by the electron gun driving motor 12 and its drive shaft 13, the number of workers needed for this operation can be reduced to 1 worker.

Therefore, with the exchange process of electron gun configured as described above, the broken gun can be replaced with a replacement gun 14 while maintaining the vacuum states of the vacuum vessel 1. Therefore, the non-operative time of the vacuum vapor deposition process can be shortened. Moreover, by automating the process of transferring the electron gun for replacement, the number of workers needed for this process can be reduced to one worker.

[Effect of this Invention]

As described above, the method for changing electron gun in the vacuum vessel of this invention provides (1) a vacuum vessel in which an electron gun is positioned at a specific location, (2) auxiliary

vacuum chamber connected to the vacuum vessel, having opening/closing valves partitioning the vacuum vessel side and air side, and (3) electron gun transfer means which transfers the electron gun for replacement to the auxiliary vacuum chamber when the air side opening/closing valve is opened while the opening/closing valve at the vacuum vessel side is closed, and transfers the electron gun for replacement to a specific location of the vacuum vessel when the opening/closing valve at the vacuum vessel side is opened while the opening/closing valve at the air side is closed. Therefore, this invention can provide a method which can change an electron gun in the vacuum vessel without disturbing the vacuum states of the inner vacuum vessel, thus reducing the time and labor needed for exchange.

#### 4. Simple Explanation of Figures

Fig. 1 is a diagram illustrating the vacuum deposit device allowing the electron gun changing method of this invention. Fig. 2 is a time schedule chart for exchanging electron guns using the electron gun exchange method in the above-mentioned vacuum vessel. Fig. 3 is a diagram illustrating the above-mentioned vacuum depositing device. Fig. 4 is a time schedule chart of the conventional electron gun exchange process in the vacuum vessel shown in Fig. 3.

1...Vacuum vessel; 6...Water-cooled pipe for electron gun;  
7...Electric wiring for electron gun; 8, 11...Vacuum pump; 10...Auxiliary vacuum chamber; 12...Electron gun driving motor; 13...Driving shaft; 14,

16...Electron gun; 18, 19...Coupling; 20, 21...Opening/closing valve;  
22...Electron gun transfer rail

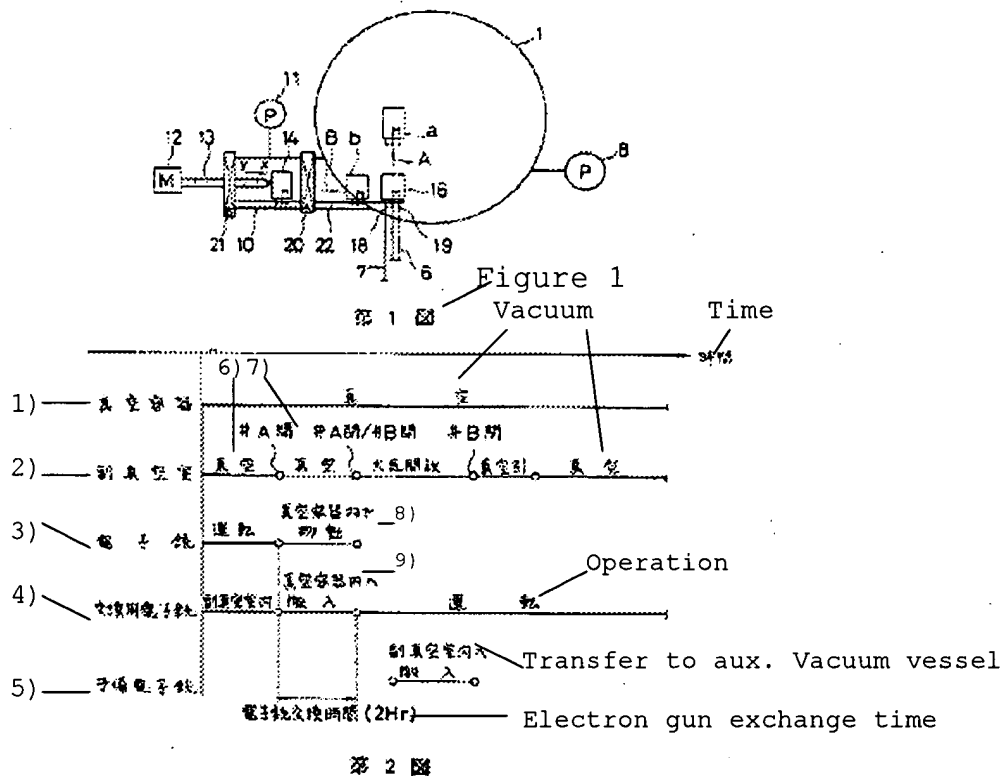


Figure 2

Key: 1...Vacuum vessel; 2...Aux. Vacuum vessel; 3...Electron gun;  
4...Electron gun for replacement; 5...Reserved electron gun; 6...Vacuumed -  
Vacuumed - Released to open air - Vacuumed;

Line 7...Open valve A - Close valve A/open valve B - Close valve B;  
Line 8...Operation - Transfer inside of the vacuum vessel;  
Line 9...In the aux. vacuum vessel - Transfer to vacuum vessel

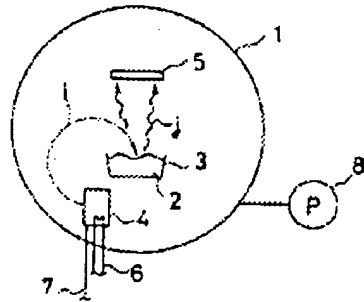


Figure 3

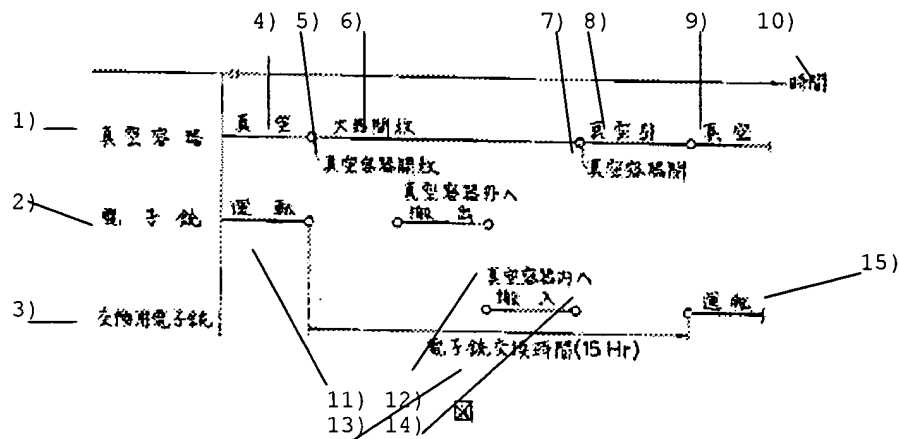


Figure 4

Key 1...Vacuum vessel; 2...Electron gun; 3...Electron gun for replacement;  
 4...Vacuumed; 5...Vacuum vessel release; 6...Release to open air; 7...Close  
 vacuum vessel; 8...Vacuum the vessel; 9...Vacuumed; 10...Time;  
 11...Operation; 12...Transfer to outside of vacuum vessel; 13...Electron  
 gun exchange time (15 hr); 14...Transfer into vacuum vessel;  
 15...Operation